A Guide To Media & Formats

Ampex Recording Media Corporation
Third Edition (NTSC)

During the past several years there has been a proliferation of new recording formats and media types for Professional and Industrial users.

By and large, the consumer formats have been the driving force, especially for the short wavelength capable, long play time tape configurations. Ampex Recording Media has developed this "quick glance" syllabus as a guideline for Ampex staff and users, with the hope that it will clarify and /or differentiate the basic characteristics of each format (both hardware and software).

Format Overview

C-FORMAT

This format reflects the third iteration of the SMPTE standard 1-inch helical video recorder. Appearing in 1978, this format was intended to add "stunt" capabilities (i.e., still-frame, picture-in-shuttle and also slo-motion) that were not possible with "quad" recorders. Also, this format brought in the use of "A.S.T." or auto scan tracking.

U-MATIC FORMAT

This was the first helical format to be widely accepted and was ultimately to find its niche in the ENG and industrial markets.

U-MATIC SP

The basic performance of the U-matic system was enhanced by this format which uses a higher coercivity tape and higher peak white frequency to achieve improved performance.

BETACAM FORMAT

This was the first of the "small format" machines intended for ENG and EFP use. Its use of an upgraded consumer format was the notable feature, as well as its being the first professional component recorder. The luminance and chroma signals are recorded on separate tracks allowing each of the two signal channels to be optimized for its particular requirements.

BETACAM SP FORMAT

This system was introduced to improve upon the Betacam format. 1500 Oe metal tape is used to increase the bandwidth and thinner tape is used to increase the play time. Betacam SP is (small cassette) compatible with standard Betacam.

M-II FORMAT

As with Betacam SP, this system was developed to increase the play time and bandwidth of the "M" format. 1500 Oe media is used with thinner tape and slower longitudinal speed to achieve these goals. Time compression multiplexing is used for the chroma signals.

Key Technical Information

Signal System

C-FORMAT	U-MATIC FORMAT	U-MATIC SP	BETACAM FORMAT	BETACAM SP FORMAT	M-II FORMAT
Analog, Composite	Analog, Composite	Analog, Composite	Analog, Component	Analog, Component	Analog, Component

Scanner Type

C-FORMAT	U-MATIC FORMAT	U-MATIC SP	BETACAM FORMAT	BETACAM SP FORMAT	M-II FORMAT
Helical, Three Heads	Helical, Two Heads	Helical, Two Heads	Helical, Six Heads	Helical, Six Heads	Helical, Ten Heads

Media Type

C-FORMAT	U-MATIC FORMAT	U-MATIC SP	BETACAM FORMAT	BETACAM SP FORMAT	M-II FORMAT
650 Oe, Cobalt Modified Oxide 1.1 mil (total thickness)	650 Oe, Cobalt Modified Oxide 1.1 mil (total thickness)	745 Oe, Cobalt Modified Oxide 1.1 mil (total thickness)	650 Oe, Cobalt Modified Oxide 0.8 mil (total thickness)	1500 Oe, MPT 0.55 mil (total thickness)	1500 Oe, MPT 0.55 mil (total thickness)

Tape Consumption

C-FORMAT	U-MATIC FORMAT	U-MATIC SP	BETACAM FORMAT	BETACAM SP FORMAT	M-II FORMAT
576 sq. in/min 48 ft/min	169 sq. in/min 19 ft/min	169 sq. in/min 19 ft/min	140 sq. in/min 23 ft/min	140 sq. in/min 23 ft/min	80 sq. in/min 13 ft/min

Electrical Characteristics

C-FORMAT	U-MATIC FORMAT	U-MATIC SP	BETACAM FORMAT	BETACAM SP FORMAT	M-II FORMAT
Head-to-Tape Speed: 1009 i/s Track Width: 5.1 mils Scanner Diameter: 5.4 inches Linear Density: 19.8 Kfrpi	Head-to-Tape Speed: 409 i/s Track Width: 3.4 mils Scanner Diameter: 4.3 inches Linear Density: 26.4 Kfrpi	Head-to-Tape Speed: 409 i/s Track Width: 3.4 mils Scanner Diameter: 4.3 inches Linear Density: 34.2 Kfrpi	Head-to-Tape Speed: 276 i/s Track Width: 3.4 mils Scanner Diameter: 2.9 inches Linear Density: 50.8 Kfrpi	Head-to-Tape Speed: 276 i/s Track Width: 3.4 mils Scanner Diameter: 2.9 inches Linear Density: 55.8 Kfrpi	Head-to-Tape Speed: 283 i/s Track Width: 1.5 mils Scanner Diameter: 3.0 inches Linear Density: 49.4 Kfrpi

D-1 (4:2:2) FORMAT

This system is a component digital machine intended for use in a complete digital studio.

The "4:2:2" refers to the sampling rate of the luminance and two chroma signal channels. The D-1 format only specifies the recorded "footprint" on the tape, and thus certain details of the machine such as "write speed" and "scanner "diameter" may vary from model to model.

D-1 machines have four digital audio tracks and longitudinal tracks for control track, SMPTE code and cue audio. The format specifies three sizes of cassettes to accommodate various applications—D-1S, D-1M and D-1L

D-2 (4fSc) FORMAT

This system is a digital composite recorder using analog inputs and outputs (i.e., the video and audio signals are digitized inside the recorder). Due to this fact, the D-2 machine can be used in present day analog studios without requiring a total (very expensive) modification of the facility, as is the case with the D-1 machine.

The "4fSc" indicates the sampling rate and the fact that it is a composite system. This system makes use of the same D-1 cassette, but with 1500 Oe metal particle tape.

Key Technical Information

	D-1	D-2
Signal System	Digital, Component	Digital, Composite
Scanner Type	Helical, Twelve Heads	Helical, Eight Heads (AST)
Media Type	850 Oe, Cobalt Modified Oxide 0.55 mil (total thickness)	1500 Oe, MPT 0.55 mil (total thickness)
Tape Consumption	508 sq. in/min 56 ft/min	234 sq. in/min 26 ft/min
Electrical Characteristics	Head-to-Tape Speed: 1192 in/s Track Width: 1.6 mils Scanner Diameter: 3.0 inches Linear Density: 55.6 Kfrpi	Head-to-Tape Speed: 1000 in/s Track Width: 1.4 mils Scanner Diameter: 3.0 inches Linear Density: 59.1 Kfrpi

Format Overview

BETA FORMAT

This was the first standardized consumer video format and uses a color-under (composite) recording system. Later Beta versions introduced the concept of "Hi-Fi" audio using an FM sub-carrier system to record high quality audio tracks.

VHS FORMAT

This system came out shortly after the Beta system and, despite its poorer picture quality, far outsells Beta due to longer play times.

The "Hi-Fi" version of this machine used a "depth" recording system for its audio tracks in which a long wavelength audio FM carrier is actually recorded under the high-frequency video FM carrier.

8mm FORMAT

This format was the first time a consumer video machine made use of an "imbedded" tracking servo rather than a longitudinal control track, thus allowing the use of very slow linear tape speeds, metal evaporated tape, and a very small cassette size. The 8mm system uses 1500 Oe metal particle tape and, when available, 950 Oe metal evaporated tape. Hi-Fi audio via an FM sub-carrier is standard with PCM digital audio as an option.

S-VHS FORMAT

This format represents an evolutionary step in the development of the VHS system. By using a higher coercivity tape, the maximum F.M. deviation frequency was increased with a resulting improvement in picture resolution. This format is "back compatible" with standard VHS tapes, and most S-VHS decks offer the option of recording standard VHS format as well.

Hi8 VIDEO

This is the 8mm version of the S-VHS concept. A higher carrier frequency is used to provide a greater F.M. deviation and thus more lines of horizontal resolution. This format has Metal Evaporated Tape as the standard with Metal Particle Tape as an optional media.

Key Technical Information

Signal System

BETA	VHS	8mm	S-VHS	Hi8
Analog, Composite	Analog, Composite	Analog, Composite	Analog, Composite	Analog, Composite

Scanner Type

BETA	VHS	8mm	S-VHS	Hi8
Helical, Two Heads	Helical, Two Heads	Helical, Two Heads	Helical, Six Heads	Helical, Two Heads

Media Type

BETA	VHS	8mm	S-VHS	Hi8
650 Oe, Cobalt Modified Oxide 0.8 mil (total thickness)	650 Oe, Cobalt Modified Oxide 0.8 mil (total thickness)	1500 Oe MPT or 950 Oe MET 0.55 or 0.4 mil (overall thickness)	850 Oe, Cobalt Modified Oxide 0.8 mil (total thickness)	950 Oe MET or 1500 Oe MPT 0.55 or 0.4 mil (overall thickness)

Tape Consumption

BETA	VHS	8mm	S-VHS	Hi8
24 sq. in/min 4.0 ft/min	39.6 sq. in/min 6.5 ft/min	11 sq. in/min 2.9 ft/min	39 sq. in/min 6.5 ft/min	11 sq. in/min 2.9 ft/min

Electrical Characteristics

BETA	VHS	8mm	S-VHS	Hi8
Head-to-Tape Speed: 275 i/s Track Width: 1.2 mils Scanner Diameter: 2.9 inches Linear Density: 34.9 Kfrpi	Head-to-Tape Speed: 228 i.s Track Width: 2.3 mils Scanner Diameter: 2.9 inches Linear Density: 38.6 Kfrpi	Head-to-Tape Speed: 150 i/s Track Width: 0.8/0.4 mils Scanner Diameter: 1.6 inches Linear Density: 66.6 Kfrpi	Head-to-Tape Speed: 228 i/s Track Width: 2.3 mils Scanner Diameter: 2.4 inches Linear Density: 61.4 Kfrpi	Head-to-Tape Speed: 150 i/s Track Width: 0.8/0.4 mils Scanner Diameter: 1.6 inches Linear Density: 102.7 Kfrpi

Format Overview

PROFESSIONAL ANALOG

Two-track audio was developed during the early days of stereophonic recording in the mid-1950s, and is still in use throughout the world today.

DASH FORMAT

"DASH" is the acronym for Digital Audio with Stationary Head, thus distinguishing it from the video recorder-based systems, such as the Sony 1610.

Multiple tape tracks are used for each signal channel as part of the ECC scheme. Machines are available in 2-track and 24-track (1/4-inch and 1/2-inch). Due to the data shuffling and interleaving, "razor blade" editing is not possible. All editing must be done through a computer-based editing system.

Manufacturers of this format are Sony, Studer, Matsushita and TEAC.

PD FORMAT

Characteristics of this system include: higher sampling rates than DASH (up to 96 kHz), and "razor blade" editing. "PD" is the acronym for Professional Digital.

Manufacturers of this format are Mitsubishi, AEG Telefunken and Otari. The PD format is an established standard.

R-DAT

R-DAT stands for Rotary Digital Audio Tape. It uses a helical video recorder-type transport to record two digital audio tracks. An imbedded tracking servo is used to allow a very narrow tape width. This is called ATF.

Key Technical Information

Signal System

Analog, Audio	Digital Audio	Digital Audio	Digital Audio

Scanner Type

N/A; Fixed Head	N/A; Fixed Head	N/A; Fixed Head	Helical, Two Heads

Media Type

350 Oe, Gamma Ferric Oxide 2.0 mil (total thickness)	650 Oe, Cobalt Modified Oxide 0.8 mil (total thickness)	650 Oe, Cobalt Modified Oxide 0.8 mil (total thickness)	1500 Oe, MPT 0.55 mil (total thickness)

Tape Consumption

228 sq. in/min 75 ft/min	113 sq. in/min 38 ft/min	113 sq. in/min 38 ft/min	2.9 sq. in/min 1.6 ft/min

Electrical Characteristics

Head-to-Tape Speed: 15/30 in/s; Fixed Head Track Width: 75 mils Scanner Diameter: N/A Fixed Head Linear Density: 2.6 Kfrpi	Head-to-Tape Speed: 7.5 in/s-30 in/s; Fixed Head Track Width: 9.5 mils Scanner Diameter: N/A; Fixed Head Linear Density: 25.4 Kfrpi	Head-to-Tape Speed: 7.5 in/s—30 in/s; Fixed Head Track Width: 12 mils Scanner Diameter: N/A; Fixed Head Linear Density: 20.3 Kfrpi	Head-to-Tape Speed: 124 in/s Track Width: 0.5 mils Scanner Diameter: 1.2 inches Linear Density: 61.0 Kfrpi

Format Overview

DCRS FORMAT

This digital cassette recording system uses a transverse scanner running at very high speed to achieve a very high data rate in a single-channel recorder. A magneto-resistive head is used for confidence playback.

ANSI PROJECT #448 (IBM 3480 STREAMER CARTRIDGE) FORMAT

This system is a 1/2-inch width, cartridge-based system using 18 parallel tracks for information interchange between information-processing systems and communication systems with standard codes for information exchange. Its main use is for backing up data from hard-disk based mainframe systems and exchange of software.

ANSI I-D-1 MIL STD. 2179

This format-in-the-works is the data recording implementation of the D-1 digital video standard. Since the video D-1 is basically a digital data recorder and is no longer locked into NTSC field or frame rates, it can be used for any type of digitally-encoded information storage.

The intent of this format is to make use of as much of the D-1 video standard as possible from the media and cassette to basic hardware.

Key Technical Information

Signal System

Digital Data Recording	Digital Data Recording	Digital Data Recording

Scanner Type

Transverse, Six Heads	Fixed Head	Helical, Eight Heads

Media Type

650 Oe, Cobalt Modified Oxide 0.8 mil (total thickness)	650 Oe, Cobalt Modified Oxide or Chromium Dioxide 1.1 mil (total thickness)	850 Oe, Cobalt Modified Oxide 0.55 mil (total thickness)

Tape Consumption

330 sq. in/min 28 ft/min	900 sq. in/min 150 ft/min	508 sq. in/min 56 ft/min

Electrical Characteristics

Head-to-Tape Speed: 2500 in/s Track Width: 1.4 mils Scanner Diameter: 1.6 inches Linear Density: 41.5 Kfrpi	Head-to-Tape Speed: 30 in/s; Fixed Head Track Width: 20 mils Scanner Diameter: N/A; Fixed Head Linear Density: 49.4 Kfrpi	Head-to-Tape Speed: 1192 in/s Track Width: 1.6 mils Scanner Diameter: 3.0 inches Linear Density: 55.6 Kfrpi

FORMAT		C	U-MATIC	U-MATIC SP	BETACAM	BETACAM SP (mode 2)	M-II
Tape Width	inches	1.00	0.75	0.75	0.50	0.50	0.50
Track Width	mils	5.1	3.4	3.4	3.4	3.44	1.52
Track Pitch	mils	6.1	4.4	4.4	3.2	3.22	1.69
T.P.I.		162.8	228.8	228.8	310.6	310.6	592.4
Film Thickness	mils	0.81	0.81	0.81	0.57/0.37	0.37	0.37
Linear Speed	i/s	9.60	3.75	3.75	4.67	4.67	2.67
Write Speed	i/s	1009	409	409	224	276.2	283.6
Scanner Diameter	in	5.35	4.34	4.34	2.93	2.93	2.99
Helix Angle	degrees	2.400	4.900	4.900	4.679	4.603	4.291
Peak White Freq.	MHz	10.0	5.4	7.0	5.7	7.7	7.0
Linear Density	Kfrpi	19.8	26.4	34.2	50.8	55.75	49.37
Bits/Sq. Inch	e 6	3.23	6.04	7.8	15.80	17.3	29.2
Bits/Cubic Inch	e 9	2.18	4.05	7.1	19.27/25.08	27.46	46.35
Component/Composite		composite	composite	composite	component*	component*	component*
Year Introduced		1978	1968	1986	1982	1986	1986
Tape Coercivity	Oersteds	650	650	745	650	1500	1500
Cassette/Reel-Reel		R/R	cassette	cassette	cassette	cassette	cassette
# Tracks/Revolution		1	2	2	4	4	4
EFF Wrap Angle	degrees	330	180	180	180	180	180
Heads On Scanner		6	4	4	6	6	10

Notes: * Time Compression

FORMAT		D-1 4:2:2	D-2 4Fsc
Tape Width	inches	0.75	0.75
Track Width	mils	1.57	1.54
Track Pitch	mils	1.77	1.54
T.P.I.		565.0	650
Film Thickness	mils	0.37	0.37
Total Thickness	mils	0.512	0.512
Linear Speed	in/s	11.28	5.19
Write Speed	in/s	1192	1078
Scanner Diameter	in	2.95	2.95
Helix Angle	degrees	5.4005	6.1296
Linear Density	Kfrpi	55.6	59.1
Bits/Sq. Inch	e 6	31.4	38.4
Bits/Cubic Inch	e 9	49.84	64.0
Component/Composite		component	composite
Year Introduced		1986	1988
Tape Coercivity	Oersteds	850	1500
Cassette/Reel-Reel		cassette	cassette
# Tracks/Revolution		4	4
EFF Wrap Angle	degrees	261	180
Quantization	bit	8	8
Sampling Rate	MHz	27.1	14.3
Input Data Rate	Mb/sec	112	60.1

FORMAT		BETA	VHS	8mm	S-VHS	Hi8
Tape Width	inches	0.500	0.500	0.315	0.500	0.315
Track Width	mils	1.20	2.30	0.81	2.30	0.81
Track Pitch	mils	1.20	2.30	0.81	2.30	0.81
T.P.I.		833	435	1230	435	1230
Film Thickness	mils	0.57/0.37	0.57/0.37	0.37	0.57/0.37	0.37
Linear Speed	in/s	0.79	1.30	0.57	1.30	0.57
Write Speed	in/s	275	228	150	228	150
Scanner Diameter	in	2.92	2.42	1.58	2.42	1.58
Helix Angle	degrees	5.85	5.96	4.88	5.80	4.88
Peak White Freq.	MHz	4.8	4.4	5.0	7.0	7.7
Linear Density	Kfrpi	34.91	38.60	66.66	61.4	102.7
Bits/Sq. Inch	e 6	29.1	16.8	82.3	26.7	126.3
Bits/Cubic Inch	e 9	35.48/46.19	20.48/26.66	130.6	29.3	200.5
Component/Composite		composite	composite	composite	composite	composite
Year Introduced		1974	1975	1985	1987	1989
Tape Coercivity	Oersteds	650	650	1500	850	950/1500
Cassette/Reel-Reel		cassette	cassette	cassette	cassette	cassette
# Tracks/Revolution		2	2	2	2	2
EFF Wrap Angle	degrees	230	180	210	180	210

FORMAT		DASH	PD	R-DAT	PROFESSIONAL ANALOG
Tape Width	inches	0.25/1.0	0.25/0.5/1.0	0.15	0.25/2.00
Track Width	mils	9.5	12.0	0.54/0.90	75.0
Track Pitch	mils	13.36	24.4	0.54/0.80	159.0
T.P.I.		74.85	44.0	1869.2/1250.0	80
Film Thickness	mils	0.57	0.57	0.37	1.50
Linear Speed	in/s	7.5-30	7.5-30	0.32/0.48	15/30
Write Speed	in/s	n/a	n/a	123.56	n/a
Scanner Diameter	in	n/a	n/a	1.18	n/a
Helix Angle	degrees	n/a	n/a	6.37	n/a
Linear Density	Kfrpi	25.4	20.3	61.0	2.6
Bits/Sq. Inch	e 6	1.9	0.89	114/76.3	0.028
Bits/Cubic Inch	e 9	2.39	1.56	181.0/121.1	0.010
Year Introduced		1983	1984	1987	1954
Tape Coercivity	Oersteds	650	650	1500	350
Cassette/Reel-Reel		R/R	R/R	cassette	R/R
# Tracks/Revolution	—	n/a	n/a	2	n/a
EFF Wrap Angle	degrees	n/a	n/a	90	n/a
Quantization	bit	16	16/20	12/16	n/a
Sampling Rate	kHz	32/44/48	44/48/96	32/44/98	n/a
Input Data Rate	Mb/sec	0.77*	1.92*	0.77*	0.02

Note: Highest rate per channel

FORMAT		DCRS	STREAMER 3480	ANSI ID-1 MIL STD. 2179
Tape Width	inches	1.00	0.50	0.75
Track Width	mils	1.35	20.30	1.57
Track Pitch	mils	1.50	24.80	1.77
T.P.I.		667	40	565
Base Thickness	mils	0.57	1.00	0.37
Linear Speed	in/s	5.5	30	1.28
Write Speed	in/s	2500	n/a	1192
Scanner Diameter	in	1.574	n/a	2.95
Helix Angle	degrees	89.91	n/a	5.4005
Linear Density	Kfrpi	41.5	49.4	55.6
Bits/Sq. Inch	e 6	27.7	1.98	31.40
Bits/Cubic Inch	e 9	33.8	1.13	49.84
Year Introduced		1985	1983	1987
Tape Coercivity	Oersteds	650	650	850
Cassette/Reel-Reel		cassette	cassette	cassette
# Tracks/Revolution	—	6	n/a	4
EFF Wrap Angle	degrees	130	n/a	261
Quantization	bit	2	2	2
Sampling Rate	MHz			
Input Data Rate	Mb/sec	200*	1.41**	200*

Notes: *User definable.
**Data rate per track.

The Magnetic Tape Division manufactures and markets a complete line of audio, video and instrumentation tapes for entertainment, education and government applications.

Audio

Ampex Studio Mastering Tape is the world's leading analog and digital mastering tape for professional recording studios worldwide. Ampex offers products for studio mastering, film and video post production, bin loop mastering and cassette duplication, and broadcast syndication.

Ampex 406/407	Audio Mastering Tape
Ampex 456	Grand Master® Studio Mastering Tape
Ampex 467	Digital Mastering Tape
Ampex 467	U-matic and R-DAT Digital Audio Cassettes
Ampex 472	Studio Audio Cassettes
Ampex 478	Low Print Mastering Tape
Ampex 615/616	Audio Cassette Duplicator Tape
Ampex 617/618	Audio Cassette Duplicator Tape
Ampex 619/620	Audio Cassette Duplicator Tape (chrome)
Ampex 631/641	Open Reel Duplicator Tape
Ampex 631/641/651/661	Open Reel Audio Tape
Ampex 632/642	Professional Open Reel Tape
Ampex 632/642	Professional Open Reel Duplicator Tape
Ampex 672	Professional Audio Cassette

Video

Ampex Professional Videotape is used for the production of top television shows and news coverage worldwide, as well as for editing, broadcast transmission, commercial spot playback, original acquisition and program syndication.

Ampex 175 — 2″	Broadcast Quadruplex
Ampex 187 — 3/4″	U-matic Broadcast Videocassette
Ampex 188 — 1/2″	Betamax Professional Videocassette
Ampex 189 — 1/2″	VHS Professional Videocassette
Ampex 199 — 1/2″	VHS Master Broadcast Videocassette
Ampex 196 — 1″	Master Broadcast Videotape
Ampex 197 — 3/4″	U-matic Master Broadcast Videocassette
Ampex 297 — 3/4″	U-matic SP Master Broadcast Videocassette
Ampex 198 — 1/2″	Betacam Master Broadcast Videocassette
Ampex 298 — 1/2″	Betacam SP Master Broadcast Videocassette
Ampex 219 — 19mm	D-1 Digital Master Broadcast Videocassette
Ampex 319 — 19mm	D-2 Digital Master Broadcast Videocassette

Instrumentation

Ampex offers a full line of precision instrumentation tape products to support all major recording applications.

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